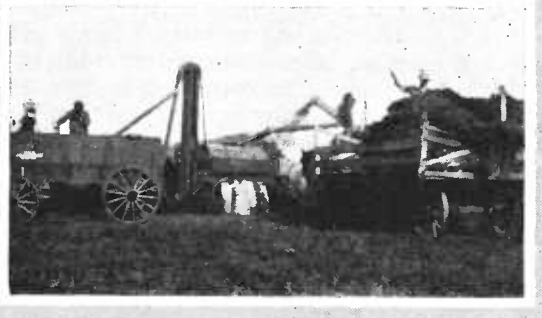
U. S. DEPARTMENT OF AGRICULTURE

FARMERS' BULLETIN No. 1542

CLEANING GRAIN ON FARMS AND IN COUNTRY ELEVATORS



WEEDS IN GRAIN cause heavy losses in the production and marketing of grain, especially in the spring-wheat area. The weight of the weed seeds and other foreign material that can be readily separated from wheat, flaxseed, and rye by appropriate cleaning devices is referred to commercially as dockage.

Excessive quantities of weed seeds in the other grains cause the grain to be assigned a lower grade. Losses from dockage can be prevented by eliminating the weeds in the stubble fields before they form seeds, by destroying the weed seeds in the soil, and by thoroughly cleaning the seed grain.

Of the 1926 crop delivered to country elevators in the spring-wheat areas of Minnesota, North Dakota, South Dakota, and Montana, the wheat contained an average of 7 per cent dockage and the flaxseed contained an average of 16 per cent dockage. During the four-year period 1923–1926 the dockage delivered by farmers to country elevators in these four States amounted to approximately 360,000 tons annually.

Clean grain commands a higher average price than does the same grain before cleaning and costs less to ship than does the grain which contains dockage.

The dockage, after being removed from the grain, is called screenings. Screenings are valuable feed for livestock and should be removed before the grain is shipped. The annual farm feed value of dockage produced in North Dakota alone is estimated at over $5,000,000.

Spring-wheat farmers are taking a greater interest in cleaning their grain before selling, and country elevator operators are finding it profitable to remove the dockage from grain before shipping to terminal markets.

Grain cleaners are available for cleaning grain at the threshing machines, in farm granaries, and in country elevators.

This bulletin supersedes Farmers' Bulletin 1287, Foreign Material in Spring Wheat.

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CLEANING GRAIN ON FARMS AND IN COUNTRY ELEVATORS

By R. H. BLACK, *Marketing Specialist, Grain Cleaning Investigations, and* E. G. BOERNER, *in Charge, Grain Investigations, Bureau of Agricultural Economics*

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LOSSES FROM WEEDS IN GRAIN

THE ENORMOUS WEED CROP that is raised with the grain every year is one of the chief reasons we do not have larger yields of grain per acre in the spring-wheat area. A typical sample of spring wheat containing weed seeds is shown in Figure 1.

Wheat, rye, and flax are the three principal cash grain crops of this area. When the grain is hauled to and sold at the local market the percentage of weed seeds and other foreign material found in it is ascertained by the grain buyer, and a weight that is equivalent to the weight of the foreign material in the grain is deducted from the weight of each load of grain before payment is made to the farmer.

The weed seeds and other foreign material found in these grains when it is sold on the market is referred to as "dockage."[1] The

[1] Dockage as specified in the Federal grain standards for wheat includes sand, dirt, weed seeds, weed stems, chaff, straw, grain other than wheat, and any other foreign material which can be removed readily from the wheat by use of appropriate sieves, cleaning devices, or other practical means suited to separate the foreign material present; also undeveloped, shriveled, and small pieces of wheat kernels removed in properly separating the foreign material, and which can not be removed by properly rescreening or recleaning. The quantity of dockage shall be calculated in terms of percentage, based on the total weight of the grain, including the dockage. The percentage of dockage so calculated, when equal to 1 per cent or more, shall be stated in terms of whole per cent, and when less than 1 per cent shall not be stated. A fraction of a per cent shall be disregarded. The percentage of dockage so determined and stated shall be added to the grade designation. Dockage in rye is ascertained in a similar manner. Dockage in the grades for flaxseed as established by the various State and other grain-inspection departments also refers to the amount of weed seeds and other foreign material found in the flaxseed and which can readily be removed by appropriate cleaning devices. Dockage in flaxseed is usually stated in terms of whole and half per cents.

process of determining the amount of dockage that is in any given lot of grain and of deducting its weight from the grain containing it is usually referred to as "assessing dockage."

For efficient results, weed seeds must be removed from wheat and rye before these grains are ground into flour and from flax-

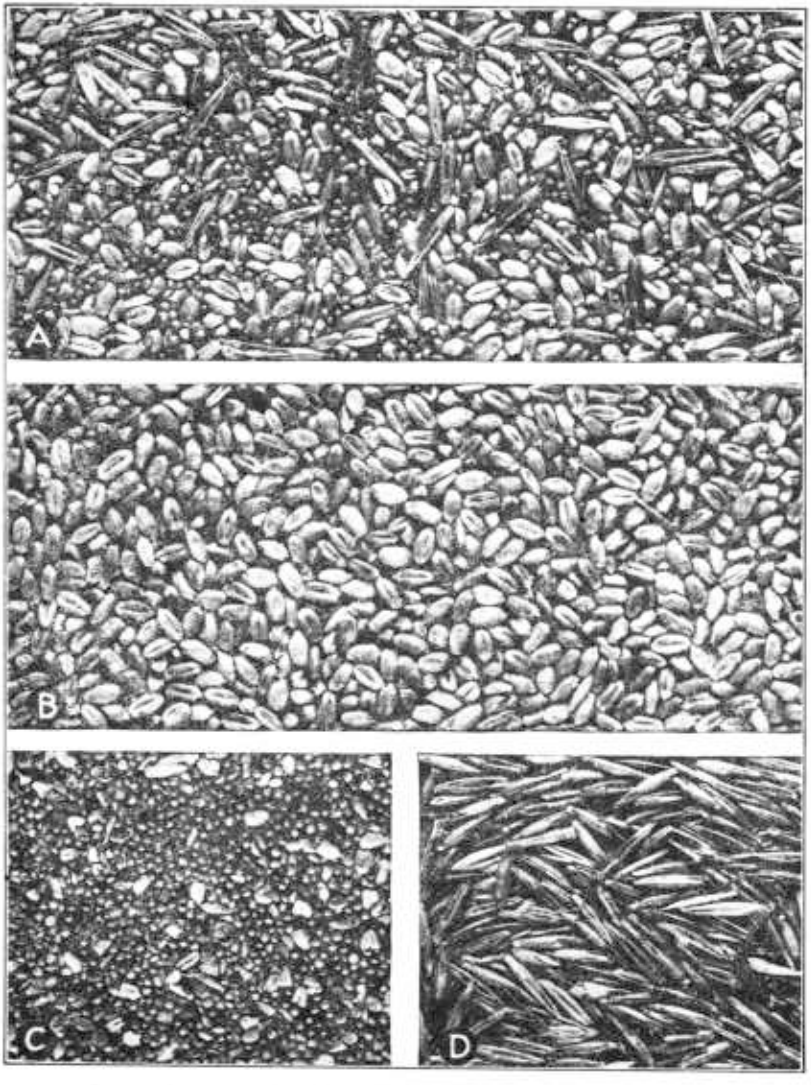


FIG. 1.—A, wheat before cleaning; B, wheat after cleaning; C, fine seed dockage; D, coarse dockage, mostly wild oats

seed before it is crushed for oil. The weed seeds and other foreign material that are removed from the grain and flaxseed are commercially called "grain screenings."

The amount of dockage found in grain has in general been steadily increasing in the spring-wheat area. (See fig. 2.)

The average dockage that is found in the wheat that is delivered to the local elevators in the spring-wheat States varies somewhat from year to year, but it is noticeable that those districts which have a high dockage in any one year, usually maintain a relatively high dockage for several succeeding years. The average dockage in the

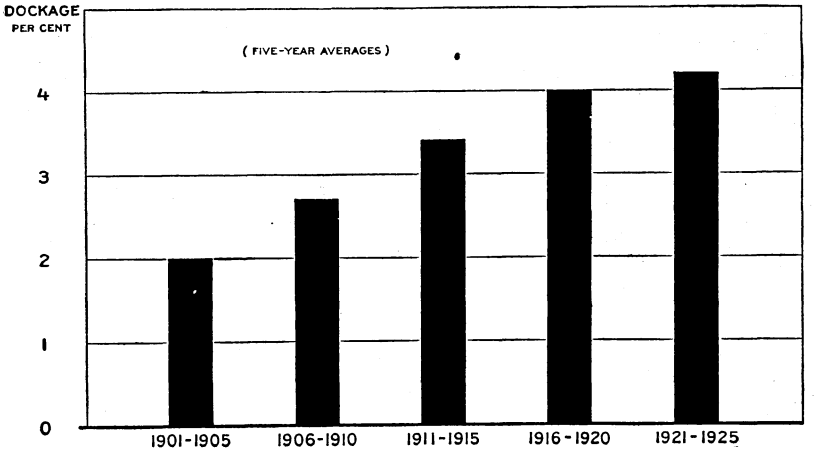


FIG. 2.—Dockage in spring-wheat receipts at Minnesota terminals. The average dockage in spring wheat, including durum, received at Minnesota terminals has increased during each succeeding five-year period

wheat delivered to country elevators in each of the four spring-wheat States during the three-year period, 1924 to 1926, is shown in Table 1.

TABLE 1.—*Average percentage of dockage in wheat and in flaxseed as delivered at country elevators, 1924–1926*

Year	Wheat					Flaxseed				
	North Dakota	South Dakota	Minnesota	Montana	Average	North Dakota	South Dakota	Minnesota	Montana	Average
1924	6.2	5.1	4.9	2.4	5.2	17.4	15.6	13.8	5.0	15.4
1925	7.4	8.7	6.9	3.1	6.9	17.8	15.8	14.2	5.1	15.7
1926	9.1	6.9	6.1	3.1	7.0	16.4	18.6	16.4	7.2	16.4

There has been an increase in the average percentage of dockage in the wheat marketed at country elevators from 5.2 in the 1924 wheat crop to an estimate of 7 in the 1926 crop. The dockage in the flaxseed has also increased from an average of 15.4 per cent in the 1924 crop to an estimated 16.4 per cent in the 1926 crop. Complete figures for the 1926 crops are not available at this writing.

The percentages of dockage shown in Table 1 do not include all the weed seeds produced in these two crops in the spring-wheat States because part of the dockage was removed on the farm before the grain was hauled to the local markets, nor do these statistics include those weed seeds which are not easily separated in ascertaining dockage, and therefore were considered as "foreign material

other than dockage" when the dockage determinations were made at the time when the grain was sold at the country elevators.

HOW WEEDS AND DOCKAGE CAUSE LOSSES

Losses caused by weeds occur in both the production and marketing of grain. Weeds in grainfields cause a reduction in the yield of grain. There are several reasons for this. Weeds in grainfields occupy space which could be occupied by grain plants, if the weeds were not there. Tall weeds like kinghead and lamb's-quarters not only crowd the surrounding grain, but shade it, which prevents the proper filling out of the grain kernels and retards the ripening of the grain.

During certain periods in nearly every year, parts of the spring-wheat area suffer from lack of moisture and during such times the weeds in the grainfields use much of the soil moisture which is seriously needed by the grain plants. Weeds also rob the cultivated crops of much of the available plant food in the soil, which tends to reduce yields. This is especially harmful when the soil is deficient in one or more of the essential plant-food elements.

Weeds in grainfields increase the cost of harvesting because for any given quantity it costs as much to harvest and handle the weeds as it does to harvest and handle the grain. Weeds likewise increase the cost of threshing, because it costs as much and often more to thresh a unit weight of weed seeds than it does for grain. Some weeds like kinghead, Russian thistle, and wild morning-glory, because of their bulky and branching nature, cause difficulty in the harvesting and threshing of the grain.

Other weeds like lamb's quarters, pigeon grass, and Russian thistle, which contain large quantities of moisture at harvest, hinder the drying of the grain in the shocks and this often causes the grain to heat in storage after it is threshed.

Further losses are incurred when grain containing weed seeds is marketed. The space occupied by weed seeds in the wagon box makes it necessary to haul more loads to market than would be necessary if the grain were clean. Roughly estimated it costs about 3 cents a bushel to haul the dockage from the farm to the country elevator. Grain containing dockage usually does not bring as high a price when it is sold as it would if it were clean. When grain that contains dockage is shipped to the terminal markets the dockage takes the same freight rates as the grain. For instance, when a car of wheat containing 5 per cent dockage is shipped from a point in North Dakota which takes a freight rate of 12 cents per bushel to Minneapolis, the freight on the dockage alone is about $8.80. When the car contains 10 per cent dockage, the freight on the dockage is over $17; if the grain contains 20 per cent, the freight for the dockage is over $35.

Many cars of hard red spring and durum wheat containing over 20 per cent dockage are received at the terminal markets each year from the spring-wheat area. (Table 2.) The cost of the freight on the dockage must be shared by each bushel of net wheat in the car, because payment for the wheat is made on the basis of the number of bushels of net wheat only in the car. In the case of a car con-

taining 20 per cent dockage, the freight cost for the wheat is increased from 12 cents per bushel to 15 cents for each bushel of actual wheat. (Fig. 3.)

TABLE 2.—*Minnesota State inspection dockage of spring wheat including durum, on arrival, by cars, for crop years beginning September 1*

Percentage of dockage	1917	1918	1919	1920	1921	1922	1923	1924	1925
	Cars	*Cars*	*Cars*	*Cars*	*Cars*	*Cars*	*Cars*	*Cars*	*Cars*
0	2,562	5,406	3,025	6,491	4,277	3,438	2,251	7,230	7,214
1	16,240	41,510	7,520	13,514	13,929	16,024	8,580	23,980	15,438
2	21,942	50,572	13,294	17,498	18,253	22,845	12,249	35,462	21,057
3	17,171	29,260	15,346	19,087	19,807	26,303	13,301	34,467	22,518
4	11,306	6,789	13,043	17,285	16,314	23,470	12,196	24,313	19,689
5	7,535	7,309	10,089	14,260	12,278	19,030	10,953	15,917	15,377
6	4,430	3,666	7,260	10,625	8,041	13,544	8,913	9,596	10,660
7	2,830	1,971	5,033	8,156	5,516	9,566	7,430	5,687	7,514
8	1,677	1,129	3,563	6,035	3,458	6,232	5,754	3,341	4,954
9	1,040	590	2,187	4,444	2,142	3,798	4,128	1,833	3,113
10 to 14	1,693	1,013	4,289	9,044	3,090	5,654	9,320	2,887	5,483
15 to 19	250	148	680	1,236	257	590	1,800	455	647
20 to 24	77	47	161	198	50	90	370	122	206
25 to 29	38	41	62	39	22	23	107	72	50
30 to 34	14	23	32	19	6	16	30	44	33
35 to 39	8	29	13	19	2	11	32	40	29
40 to 44	11	20	26	5	4	7	17	45	25
45 to 49		5	16	12	1	3	35	46	23
50 and over	8	12	24	9	5	4	13	4	2
Total	88,832	149,540	85,663	127,976	107,452	150,648	97,479	165,541	134,032
Average, per cent	3.55	2.42	4.43	4.57	3.82	4.23	5.29	3.42	4.12

Flaxseed receipts at the terminal markets usually contain more dockage than do the same quantities of wheat. The average dockage in the flaxseed receipts at Minneapolis for the 1925 crop was 15 per cent.

Since under ordinary circumstances no money is obtained for the weed seeds or dockage when the grain is sold at the country markets, every bushel of grain sold from the farm must bear its proportional share of the expense of growing, harvesting, threshing, transporting, and marketing the weeds.

The United States Department of Agriculture has estimated that the spring grain crop is reduced each year from 12 to 15 per cent on account of weeds. This is discussed in full in yearbook separate No. 732 which also points out that, in addition to a loss in both the quantity and quality of grain produced, there is an increase in the cost of production and marketing caused by the weeds in the grain. Weeds also provide harbors for insects and disease which in turn further contribute their share to the reduction of both the quality and quantity of the grain.

LOSS IN NORTH DAKOTA FROM WHEAT DOCKAGE

North Dakota produces more spring wheat than any other State. For the 1926 crop in this State the average spring-wheat yield was 8 bushels per acre. The average dockage in the 1926 crop of spring wheat as threshed in the State was 9.1 per cent. (See fig. 5.) From these figures it appears that on an average each acre of wheat, in addition to producing 8 bushels of wheat, also produced 48.1 pounds of dockage, and that on this basis the average production of weed-seed dockage for each quarter section was 7,696 pounds. Had the

soil and seed wheat been free of weed seeds, and had the weed-seed dockage been replaced by an equal quantity of wheat, the farm value per quarter section of this additional wheat at $1.17 per bushel would have been $150.07.

In addition to the fact that the producer loses this $150.07 per quarter section, there was also an expenditure of cash and labor to produce the dockage. At a cost of $6.86 per acre [2] for twine, cutting, threshing, marketing, and overhead, the cost of producing and marketing the wheat and dockage from a quarter section was $1,097.60. This cost does not include the expense of plowing or other incidentals, but includes only those expenses which are incurred after

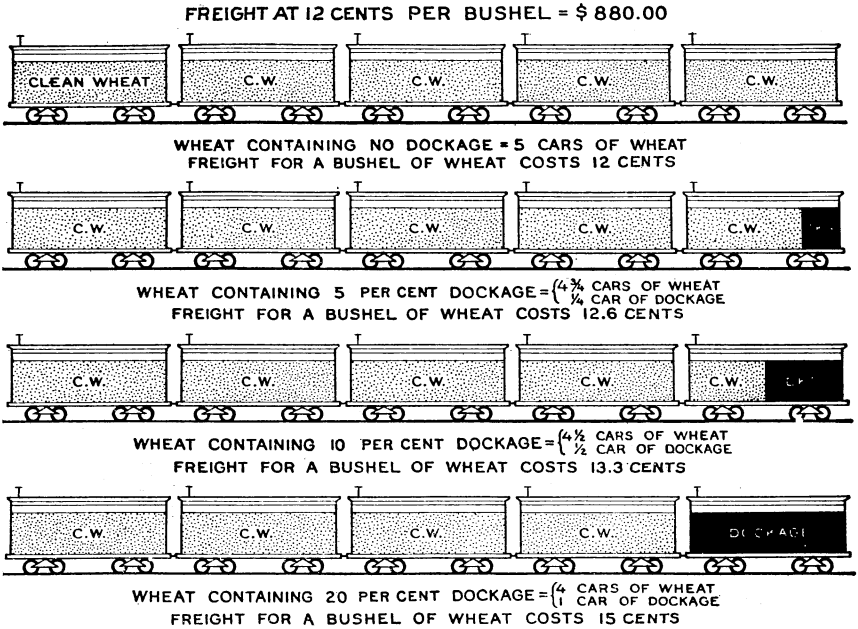


FIG. 3.—Five carloads of wheat (88,000 pounds per car). Dockage in grain decreases car space and causes an increase in the cost of freight for the grain. At a freight rate of 12 cents per bushel the freight cost for five carloads of wheat is $880, and this total cost remains the same whether the wheat is clean or contains dockage

the crop is grown. The proportion of this expense which should be charged to the dockage, 9.1 per cent, is $99.88. This indicates that the average North Dakota farmer not only spent nearly $100 in harvesting and marketing the dockage from each quarter section of wheat, but also lost a possible revenue of $150 in the value of the wheat that might have been raised in place of the weeds.

The estimated amount and farm value of the dockage produced in the wheat, flaxseed, and rye compared to the amount and value of corn, oats, and barley produced in North Dakota during the five-year period 1922–1926 is illustrated in Figure 4. It will be noted from the chart that the average annual production of dockage in

[2] BUREAU OF AGRICULTURAL ECONOMICS. Table 22, U. S. Dept. Agr., Statistical Bul. 12, 118 pp., 1926.

that State has been nearly as much as the production of corn and about two-thirds as much as barley, whereas the farm value of the dockage was less than one-half the value of the barley crop.

Some additional losses to the grain producers, as outlined before include the weed seeds that shatter and fall on the ground before and after cutting which tend to reduce the yield of future crops; the lower price which is received for the grain because it contains the weed seeds when sold on the market; and the removal of the comparatively large amounts of moisture and fertility from the soil in the production of the dockage which had a tendency to reduce the yield of the wheat.

Other States in the spring-wheat area suffer a similar loss, the amount depending upon the percentage of weeds found in their grain. The average percentage of dockage in the spring wheat

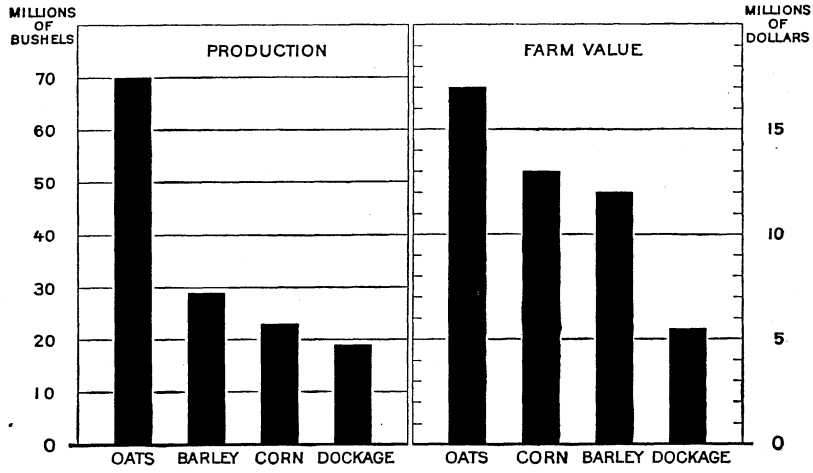


FIG. 4.—Production and value of feed grain crops and of dockage in North Dakota. During the five-year period 1922–1926 the average annual production of dockage has been nearly as much as the production of corn and about two-thirds as much as of barley; whereas the farm value of the dockage crop is less than half the value of the barley crop

as threshed in the four principal wheat States in 1926 was as follows: North Dakota, 9.1 per cent; South Dakota, 6.9 per cent; Minnesota, 6.1 per cent; and Montana, 3.1 per cent (fig. 5).

LOSS IN MINNESOTA FROM FLAXSEED DOCKAGE

Minnesota was the principal flaxseed-producing State in 1926 and in that year produced an average of 9.4 bushels of flaxseed per acre. The average acre sowed to flax also raised 103.3 pounds of dockage. The average dockage in the flaxseed as produced in this State was 16.4 per cent. (Fig. 6.) The average farm price of flaxseed in Minnesota on December 1, 1926, was $1.97 per bushel. Therefore it appears that had this dockage been flaxseed instead of weed seeds it would have been worth $3.63 per acre and for a full quarter section would have been worth $580.80.

Flaxseed receipts at the terminal markets usually contain more dockage than do the same quantities of wheat. The average dockage

in the flaxseed receipts at Minneapolis for the 1926 crop was 15 per cent.

Assuming that the cost of harvesting, threshing, and marketing wheat and flax seed are the same and using the figures for cost of harvesting, threshing, and marketing wheat for Minnesota [3] the farmers of this State made a direct outlay at the rate of $205.20 for producing the dockage on the average quarter section in flax.

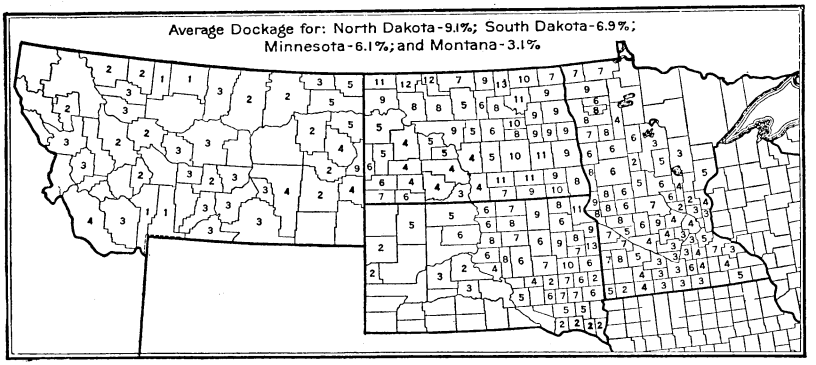


FIG. 5.—Dockage in spring wheat as threshed in 1926. The average percentage of dockage by States and counties of the four principal spring-wheat States

CAUSES OF DOCKAGE

Weeds are found in grainfields either because weed seeds have been sown with the seed grain or because the soil contained weed seeds which had shattered from previous crops. Practically all of the weeds now found in grain were originally introduced into the wheat fields in seed grain. Most of the new kinds of weeds, introduced

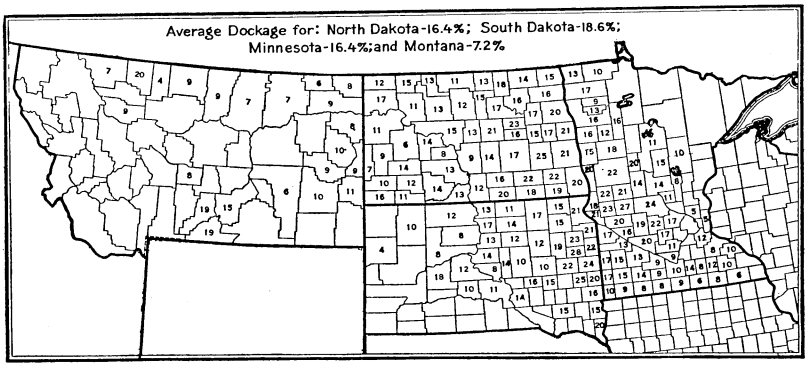


FIG. 6.—Dockage in flaxseed as threshed in 1926. The average percentage of dockage by States and counties for each of the four principal flaxseed States

into the spring-wheat area within the last few years, have come through either grass seed or through seed grain brought from other areas.

Some weeds like the sow thistle are also blown by the wind from neighboring fields; other weed seeds are carried to clean grounds to

[3] See footnote 2.

some extent by flood water, birds, and threshing machines; and are carried in feeding stuffs which contain weed seeds and which have not been properly ground before feeding.

After the weed seeds have been sown with the grain or have reached the grain fields by some other means, their increase is natural. Many weeds, like wild oats, mature part of their crop before the grain is removed from the field, and the seeds from such weeds are scattered on the ground before and during harvest. Many of such seeds are plowed under before they have had an opportunity to sprout and some do not sprout for several years. The number of weed seeds found in soil which has been continuously raising grain crops is almost unbelievable.

Most kinds of weed seeds will remain in the soil in a viable state for several years and will germinate and grow into plants whenever they are brought near the surface through plowing or other cultivation.

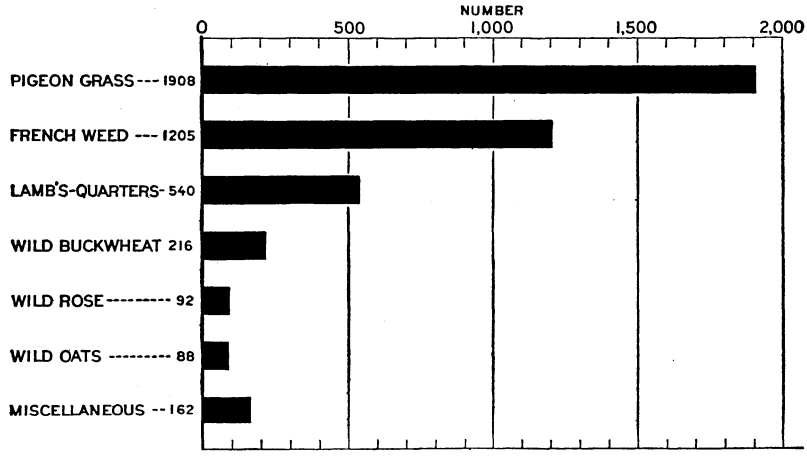


FIG. 7.—Weed seeds found in 1 square foot of soil. One square foot of soil taken from a grainfield that had been continuously cropped to wheat for 15 years was found by North Dakota experiment station officials to contain over 4,200 weed seeds

At the North Dakota Experiment Station, located at Fargo, a square foot of soil, 5 inches deep taken from a field that had been cropped to wheat each year for 15 years was found by the station officials to contain 1,908 pigeon grass, 1,205 French weed, 540 lamb's-quarters, 216 wild buckwheat, 92 wild rose, 88 wild oats, and 162 miscellaneous weed seeds—a total of 4,211 weed seeds per square foot or 183,000,000 weed seeds per acre. (See fig. 7.) Wheat is sown at a rate of slightly less than 1,000,000 wheat kernels per acre.

PREVENTION OF DOCKAGE

DESTROYING WEED SEEDS IN THE SOIL

The usual method of destroying weeds in the soil is by crop rotation, using either cultivated or forage crops. Rotations which contain only grain crops, like wheat, barley, oats, rye, and flax, will not destroy the weeds in the soil but ordinarily will increase their number. Cultivated crops like corn, potatoes, and beets encourage the

sprouting of the weed seeds and proper cultivation of these crops destroys the weeds after the seeds have sprouted. Forage crops like alfalfa and sweet clover prevent normal growth of the weeds and thus prevent their seed production. By smothering such weeds these crops assist in cleaning the soil.

There is a general supposition that most of the weed seeds that are in the soil will rot within a few years, but this is not true of many of the worst weed seeds found in the spring-wheat area. In an experiment begun in 1902, by J. W. T. Duvel, of the United States Department of Agriculture, 107 species of seeds were buried in pots of soil at various plowing depths in a field of the Arlington Experiment Farm at Rosslyn, Va. In 1912, 10 years after being buried in the soil, 69 species grew; and in 1923, after being buried for over 20 years, 51 species grew. It is evident that the seeds of most weeds when plowed under will not perish during the period of any normal crop rotation.[4]

ELIMINATING WEEDS BEFORE THEY FORM SEEDS

Some of the weed seeds lying on or near the surface of the ground can be destroyed by disking immediately after the grain is cut. Such disking causes most of the seeds to sprout before frost and then the frost kills the weeds before a new crop of seeds can be produced.

Other weed seeds, like pigeon grass, usually mature on a stem that is shorter than wheat so that many of them are not removed with the grain. Often the pigeon-grass plant does not mature seed until after the grain crop has been cut. Thorough disking immediately after the cutting of the grain crop will also kill those plants which have not yet matured seeds.

In some localities it is a common practice to run sheep on the grainfields immediately after the grain is removed so that the sheep eat and destroy the pigeon grass and other weeds, which will grow and mature seeds at that time of the year if allowed to remain undisturbed in the stubble.

ELIMINATING WEED SEEDS FROM SEED GRAIN

In addition to eliminating the weed seeds from the soil, and disposing of the weeds before they form seeds, clean seed grain must be planted if dockage-free grain is to be produced. This means that all seed grain must be carefully cleaned before it is sown. Several types of cleaning machines which will remove practically all of the weed seeds found in the seed grain are now available on the market.

UTILIZING THE DOCKAGE

Screenings (dockage) make valuable feed [5] and should be kept on the farm where produced. The average screenings are roughly comparable to oats in composition. Heavy screenings from which the

[4] M. W. Talbott, botanist in the Bureau of Plant Industry, furnished much of this information about methods for eradicating weeds from the grainfields. See also W. L. Goss, VITALITY OF BURIED SEEDS. Jour. Agr. Research, XXIX: 349, 1924.

[5] Sheets, E. W., and Jackson, William. A HANDBOOK FOR BETTER FEEDING OF LIVESTOCK. U. S. Dept. Agr. Miscel Cir. 12, 48 pp. 1924.

chaffy material has been removed are nearly equal to corn, wheat, or barley in percentages of the various nutrients. Until recently spring-wheat farmers have not generally taken advantage of the fact that dockage has considerable feeding value.

The meat packer's chief business is that of processing and selling meat, just as the grain farmer's business is to grow and sell grain, but the packer makes profitable use of every by-product of the packing business. In somewhat the same way the grain farmer can make profitable use of the dockage which he has produced at a heavy expense. By salvaging as much of the dockage as possible the grain farmer has an opportunity to make additional profits from his farming operations. In order to avoid contamination of the soil from the screenings that are used for feed, it is important that all screenings be thoroughly ground before they are fed, except when fed to sheep.

GAINS FROM CLEANING GRAIN BEFORE MARKETING

In recent years many grain farmers, recognizing the feeding value of dockage, are taking a greater interest in cleaning their grain on the farm or in having it cleaned at the country elevators and utilizing the screenings as feed for livestock. Country elevator operators, recognizing this demand for screenings, are making a greater effort to clean the grain before shipping it to market.

An analysis of the audit statements of a selected group of farmers' elevators in the spring-wheat area for two seasons by W. J. Kuhrt, Bureau of Agricultural Economics, brought out the fact that 20 farmers' elevators in North Dakota shipped 3,465,680 pounds of screenings during their fiscal year 1924–25 and received net returns of $21,629.26. The following year 26 farmers' elevators in North Dakota, Montana, and Minnesota sold 9,515,505 pounds of screenings and received a net return of $43,551.16, an average of $1,675 per elevator. The elevator in this group that made the smallest amount from screenings received a net return of $256.15; the elevator that made the largest amount from the sale of screenings received $7,411.48.

In a report made to the United States Department of Agriculture in 1926 by 90 elevators that had installed new cleaners during the three previous years, the managers estimated their annual net gains from grain-cleaning operations, including sales of screenings and income from custom cleaning, to be from $525 to $6,745. The average return to the group was $2,156. At those stations where the local demand for screenings has not yet developed to a point where all the screenings can be used locally country elevator operators can ship their wild-oats screenings to the terminal markets, where it can be officially graded under the Federal standards for grain as "mixed feed oats" and can be sold as such. There is now a good demand for mixed feed oats, and large quantities of them are sold and shipped to country points throughout the United States and to foreign countries. During the 1926 crop year dockage sold locally at country points at $10 to $22 per ton, with an average price of about $16 per ton.

Cleaning machines are available in some localities for removing the dockage from the grain at the time of threshing, but where such thresher recleaners are not available, farmers who are equipped with proper storage facilities can remove the dockage from the grain after

it has been put into the granaries and before the grain is sold. Lacking either of these facilities, a farmer can usually have his grain cleaned at the country elevator for a nominal charge. Country elevator operators, and especially those located in the spring-wheat belt, are finding that their grain-cleaning operations are adding materially to the profits from their elevator operation and, in fact, the managers of a number of the elevators estimate that a greater profit is made in some years from grain-cleaning operations than from all other sources of income.

Clean wheat commands a higher price than dirty wheat. In his analysis of the audit statements of farmers' elevators, Kuhrt found that during the period of July 1 to December 3, 1925, out of the 1,635 cars of wheat shipped by the elevators in the group, those cars containing dockage sold for 2.2 per cent less than those cars of equal grade which were dockage free. In a four-year test, beginning with the 1923 crop, several hundred thousand bushels of grain were

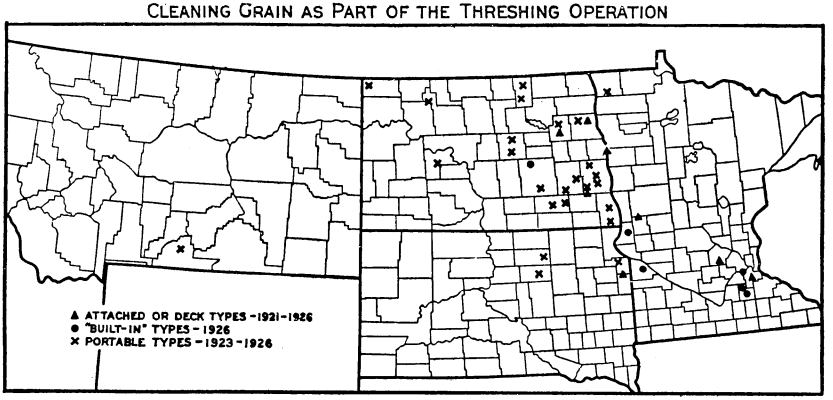


FIG. 8.—Location of experimental grain cleaners. Experiments with portable, attached, and "built in" types of grain cleaners designed for cleaning grain at the threshing machine as part of the threshing operation were conducted in the four principal spring-wheat States during the threshing seasons from 1921 to 1926. The map shows the points at which the three types of cleaners used in the experiments were operated

cleaned at threshing machines with various special types of cleaners. The locations of these cleaners are shown in Figure 8.

Each year samples of both the grain as threshed and of the grain after passing through the cleaners were taken from the fields where the cleaners operated. After each threshing season these sets of samples were submitted to several mill and elevator grain buyers at Minneapolis for bids. Precautions were taken which made it impossible for the buyers to determine which samples were pairs and only one bidder at a time was permitted in the office when the bids were made. Such bids were secured on more than 300 samples of wheat representing the varying kinds and qualities of wheat produced in the spring-wheat section during these four crop years. The average of these bids for the clean wheat was 1.8 cents higher than the average for the dirty wheat. The increased price bid for the clean grain was due principally to a better general appearance of the grain after cleaning. The cleaned grain also had a somewhat higher test weight per bushel and had fewer sprouted kernels.

Based on the results secured by the investigators during the four crops years, 1923 to 1926, the following rough estimate is made of the approximate gains that might have been made if all of the wheat in the four spring-wheat States had been cleaned before being shipped to the terminal markets. These figures are based on a total of 663,000,000 bushels of wheat marketed from the four States during the four crop years beginning in 1923.

Value of the feed in the dockage if used on the farms where grown, 1,438,704 tons at $16 per ton	$23,019,264	
Saving in hauling 89,919,000 bushels (32 pounds each) at $3 per 100 bushels of dockage	2,697,570	
Gain in price on 663,000,000 bushels of wheat at 1.8 cents per bushel	11,934,000	
		$37,650,834
Cost of cleaning at 2 cents per bushel		13,260,00
Net gain which would have been made by the farmers of North Dakota, South Dakota, Minnesota, and Montana by cleaning all of the wheat which they marketed during the four crop years 1923–1926		24,390,834

The screenings which could have been cleaned out of the wheat held for seed purposes would have amounted to approximately 227,000 tons, worth approximately $3,632,000. This makes a total farm value of over $26,000,000 for the screenings which could have been removed from the wheat raised in these four States during these four crop years.

KINDS OF WEEDS IN GRAIN

Nearly 300 varieties of weeds have been found in grainfields in the spring-wheat area. The seeds of these weeds differ considerably in size, shape, and specific gravity. Representative kernels of 12 kinds of the most common weeds are shown in Figure 9.

GRAIN CLEANERS

Several types[6] of grain-cleaning machines are used to separate the weed seeds from the grain. Some types of cleaners are manufactured in various styles suited for use on threshing machines or in farm granaries, or in country elevators; other types of cleaners are built for use at only one or two of these places. Some types of cleaners can be used for removing practically all kinds of weed seeds from nearly all kinds of grain; others remove only certain sizes or shapes of weed seeds or other grains. In general, the cleaners that are equipped with sieves separate according to the diameter of the kernels; the cleaners that are equipped with pockets or angle screens separate according to the length of the kernels; the other types of cleaners depend for their separating ability either upon the difference in the specific gravity of the seeds, or upon the shape of the kernels.

SIEVE AND AIR MACHINES

Most of the grain cleaners used in the spring-wheat area until the last few years used both sieves and air to remove the screenings

[6] Since it is impossible to describe these various cleaners in their order of value and importance because of the variations of their uses and the continual improvements which are being made in cleaning machinery, the authors do not imply that the first cleaners described have greater merits than the last cleaners described, nor does the ommission of any type of cleaner imply discrimination against such cleaner.

from the grain. When cleaners of this type are used on the farms they are called fanning mills; those of this type which are used in

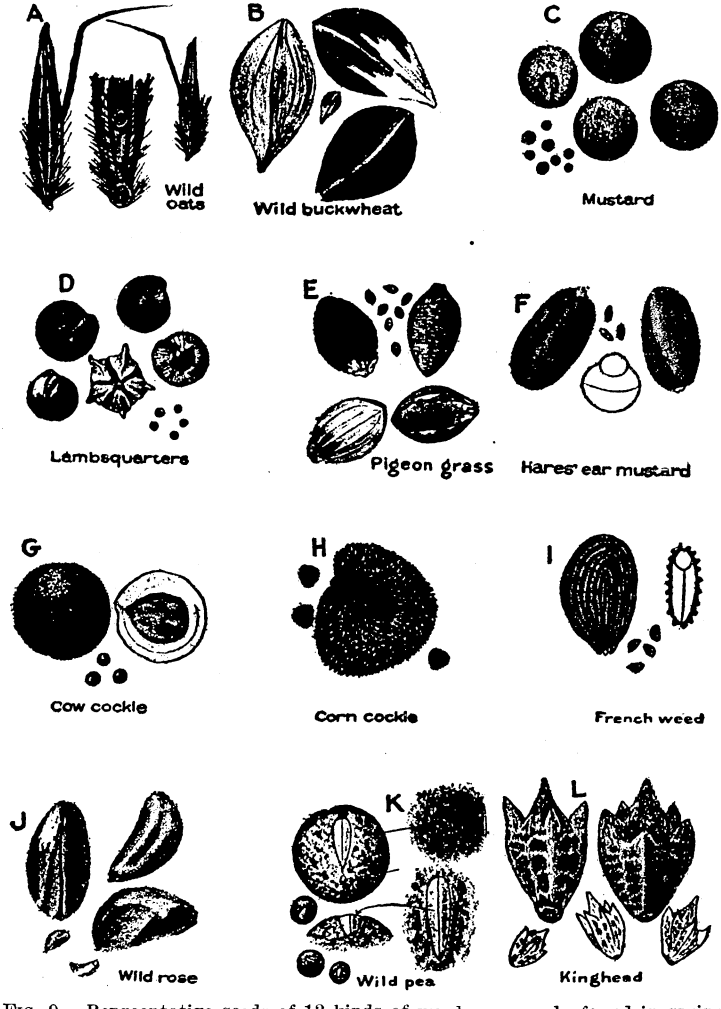


FIG. 9.—Repreentative seeds of 12 kinds of weeds commonly found in spring wheat:

A. Wild oats	*Avena fatua.*
B. Wild buckwheat	*Polygonum convolvulus.*
C. Mustard	*Sinapis arvensis.*
D. Lamb's-quarters	*Chenopodium album.*
E. Pigeon grass (green foxtail)	*Chaetochloa viridis.*
F. Hare's-ear mustard	*Conringia orientalis.*
G. Cow cockle	*Vaccaria pyramidata.*
H. Corn cockle	*Agrostemma githago.*
I. Wild rose	*Rosa* sp.
J. French weed	*Thlaspi arvense.*
K. Wild pea	*Vicia angustifolia.*
L. King-head	*Ambrosia trifida.*

elevators are usually referred to by the individual trade name. One type of fanning mill is shown in Figure 10.

Self-cleaning sieves in recent years have been installed in a number of threshing machines.

Fanning mills designed for either farm or elevator use are of two general types—side-shake and end-shake. The side-shake fanning mills use gangs of sieves in the upper part of the mill to remove coarse material. Shaking sidewise with the flow of the grain, prevents coarse material like wild oats from upending and passing through the sieve; in this way large quantities of grain can be cleaned in a short time with little loss of wheat.

In the end-shake fanning mills the sieves shake in the direction of the flow of the grain. In these machines the grain to be cleaned slides down the sieve under oilcloth or wood strips or over occasional blank metal strips in the sieves that keep the wild oats from upending. The end-shake fanning mills, in which either single upper screens or gangs of sieves are used, are particularly suited for cleaning flaxseed, clovers, and grass seeds.

The number of sieves used and the pitch at which they are set vary in the different types of fanning mills. Operating directions

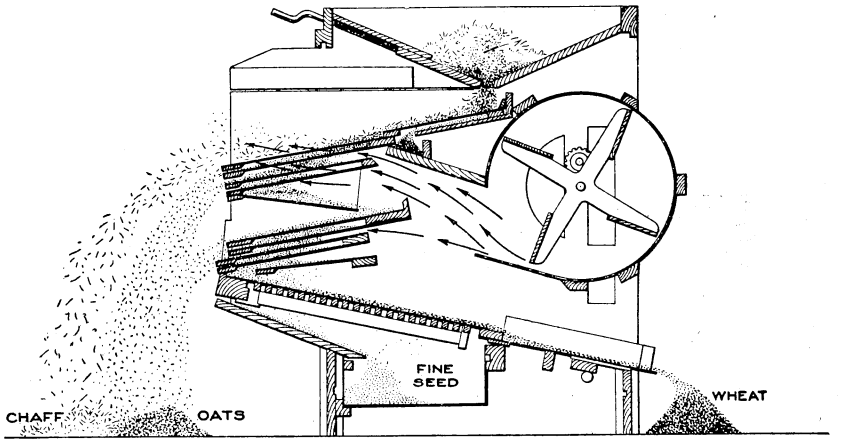


FIG. 10.—Cross section of farm fanning mill in operation

are furnished by the manufacturer of each type of fanning mill. These are printed on cardboard and usually are attached to the fanning mill. If the directions are followed carefully good results can be obtained. In case the results are not satisfactory, it is advisable to send a sample of about 1 quart of the grain to be cleaned to the manufacturer of the fanning mill, asking for instructions to cover that particular kind of material. If the size of the openings in the sieves originally furnished is at fault, new sieves with the proper sized openings should be bought. The cost of the additional sieves will usually soon be repaid in the results obtained.

For cleaning seed wheat the fanning mill must be adjusted closely for best results. A satisfactory adjustment for cleaning hard red spring wheat for seed is to use a top sieve with perforations just large enough to let the wheat kernels pass through. The feed should be so adjusted that the flow of grain will keep the top sieve well filled with wheat. This will cause the coarse material like wild oats, barley, chaff, and straw joints to ride along on the top of the wheat and tail

over the end of the sieve. If oats, wild oats, or barley are present in large quantity, it may be necessary to increase the feed to the point of allowing a small quantity of wheat to tail over with the coarse material in order to insure the removal of a large percentage of the oats and barley. The air blast should be adjusted to blow out the dust, many of the wild oats, and the light, immature, and diseased wheat kernels. The bottom sieve should have perforations large enough to let the weed seeds and cracked wheat pass through. Ordinarily a triangular buckwheat screen (fig. 11, E) is used.

Durum wheat, because of the large size of the kernels, is more difficult to clean than is hard red spring wheat, although it may con-

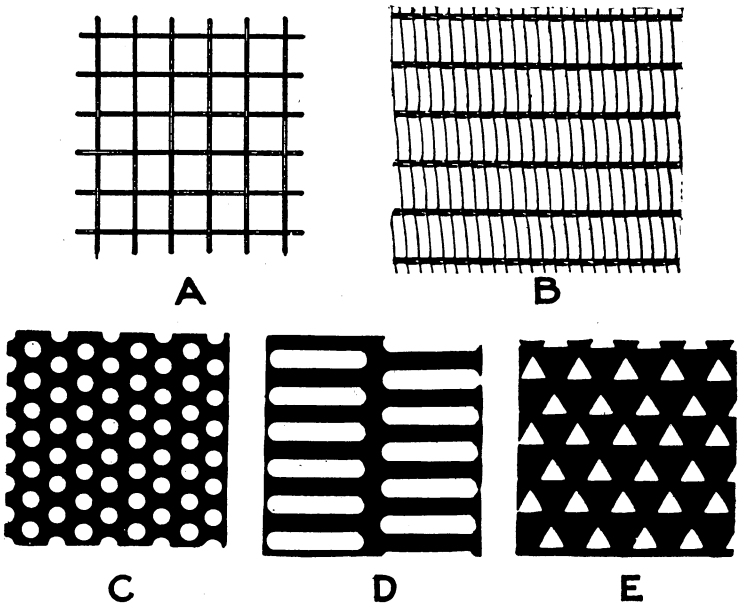


FIG. 11.—Types of wire-mesh screens and perforated sieves. Wire-mesh screens are made of specially woven wire and their sizes are designated by the number of openings in a linear inch. A, 5 by 5 square-mesh screen; B, 4 by 16 wire-mesh screen. Perforated sieves are made of sheet zinc or steel and their sizes are designated by the size of the openings. C, 3/32 round hole—diameter of opening; D, 1/2 by 0.070 slotted, extreme length and breadth of opening; E, 3/4 triangular, or buckwheat, length of any side of opening

tain practically the same kinds of weed seeds. Often durum wheat kernels are more nearly the same length as the wild oats and barley kernels, and it is difficult to separate material of this type from the wheat with the ordinary fanning mill.

In cases where there are large quantities of foreign material to be removed from seed wheat it may be necessary to run the wheat through the fanning mill several times to do a good job of cleaning. The screenings obtained from cleaning seed wheat often contain some wheat that is fit for commercial purposes; by running the screenings through the fanning mill much of this wheat can be reclaimed. But in many cases the quantity of wheat in the screenings will not justify the time and expense required for cleaning the screenings. When

this is the case the value of the wheat is not lost if the screenings are ground and fed to poultry or to livestock.

An elevator type of sieve and air machine is shown in Figure 12. It is really a large-capacity fanning mill with numerous refinements and adjustments not found on the ordinary farm-size fanning mill.

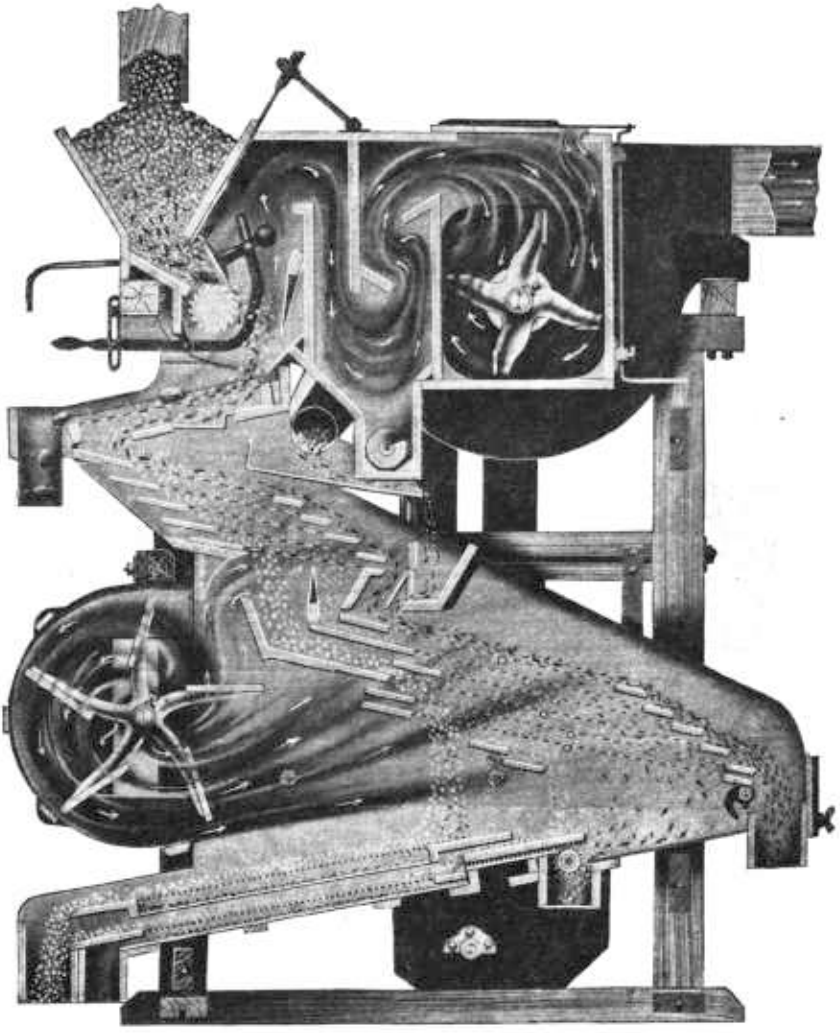


FIG. 12.—Cross section of elevator type of grain cleaner using air and sieves. In this type of grain cleaner air suction removes chaff and dust as the grain is fed into the cleaner and shaking sieves separate the dockage from the wheat. The air blast from the lower fan assists in floating the coarse material over the lower ends of the upper sieves

The lower seed screen is usually discarded in threshing machines that operate in the spring-wheat area because if it is left in the thresher the perforations or meshes soon become filled with wild oats, after which the sieve not only ceases to function but the wild oats that stick in the sieve prevent the flow of grain into the grain

auger and cause much of the grain to be blown out with the straw. These troubles have been overcome by use of the self-cleaning screen shown in Figure 13. This screen also removes much of the small-sized weed seeds from the grain.

The self-cleaning screen is designed to replace the regular fine-seed screen in the shoe of the thresher. When the self-cleaning screen is used the cleaning racks are firmly attached to the thresher frame and remain stationary. The motion of the thresher shoe, in which the screen is locked moves the screen backward and forward over the cleaning racks which remove the wild oats that stick in the screen.

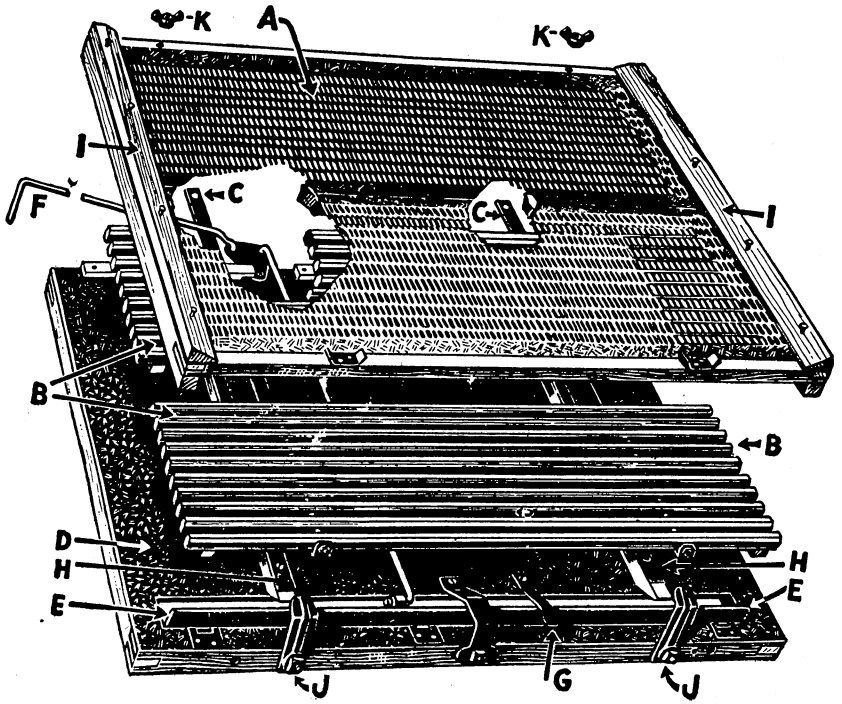


FIG. 13.—Working parts of self-cleaning threshing screen. A, long oval mesh of zinc; B, cleaning rack of air-dried birch soaked in oil; C, rack irons bolted by individual attachments to threshing machine; D, sheet-metal bottom for dockage to slide away on; E, dockage gate, open; F, hand lever controlling dockage gate; G, spring to hold gate in either open or closed position; H, iron-shod slides for cleaning rack; I, side strips, adjustable to fit width of threshing machine; J, clamps to hold assembly together; K, wing nuts

Ordinarily the screenings removed by this screen fall to the ground, but a gate at the lower end of the screen can be closed so that, if desired, the screenings can be remixed with the grain. This prevents the necessity of changing screens for many small lots of grain which are threshed but are not to be cleaned.

KICKER OR ANGLE-SIEVE MACHINES

The wild-oat kicker shown in Figure 14 is the most commonly used of the angle-sieve type. The angle sieve or riddle is so constructed that the wheat kernels pass through the angle in the throat,

while the oats, being too long to pass through this angle, are kicked backward in the direction of the throw of the riddle and are event-

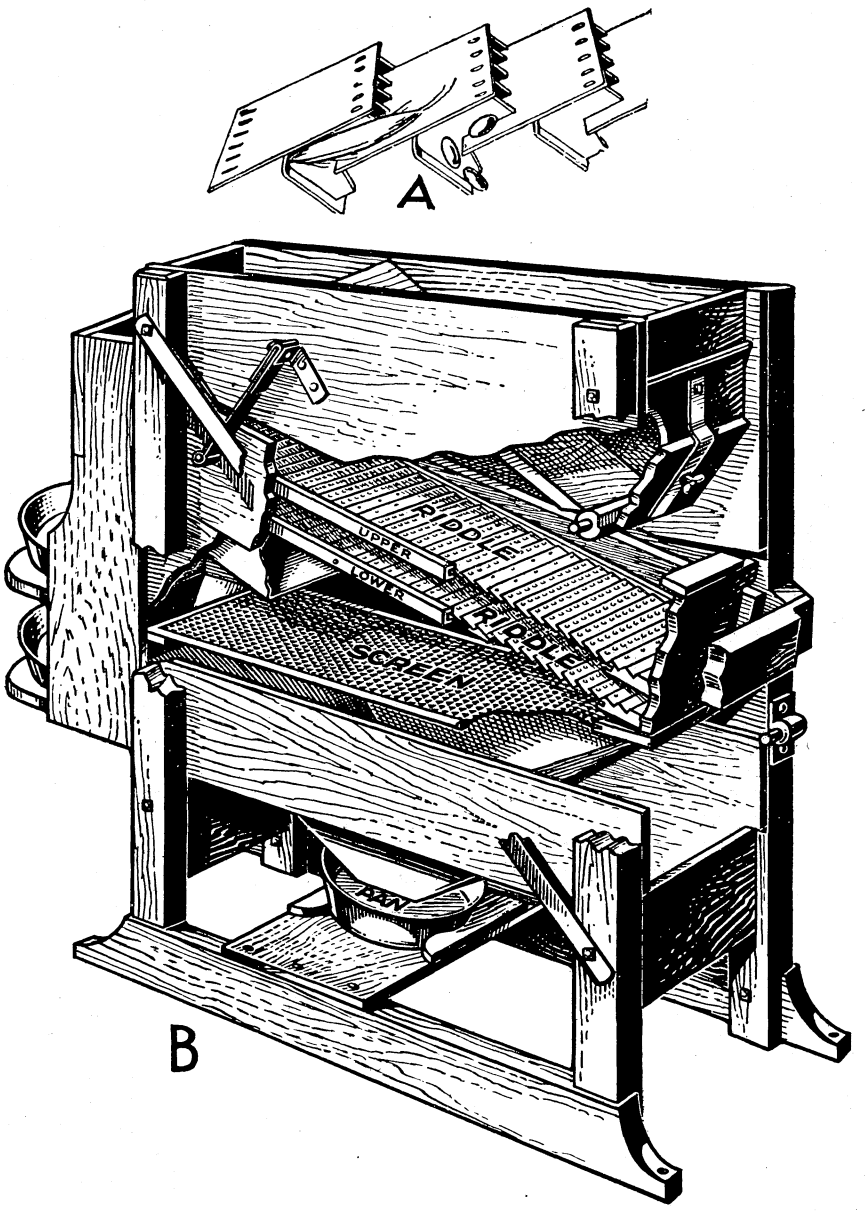


FIG. 14.—Wild-oat kicker. A, section of an angle sieve or riddle through which the wheat passes, but which has angular throats too small to permit passage of oats; B, cross section of assembled dockage tester

ually discharged from the machine. The wheat kernels and the fine seeds which drop through the angle in the sieve fall to a fine-seed screen below, which removes the small weed seeds from the

grain. The machine illustrated is used in assessing dockage when wheat or rye is inspected and graded under the provisions of the United States grain standards act, but commercial farm-size machines of this same type are also built in three and six riddle sizes which have respectively three and six times the capacity of the dockage machine. By using perforated slotted screens in place of the wheat riddles, flaxseed can be cleaned with the kicker type of cleaners.

POCKET MACHINES

The principal pocket machines use pocketed vertical disks, indented cylinders, or indented belts. All of the pocket machines work on the principle of length separation. (Figs. 15, 16, and 17.) In cleaning wheat, the weed seeds that are shorter than the wheat kernels fall into and remain in the pockets, as the disk, cylinder, or belt, as the case may be, moves upward through the grain and the weed seeds are carried out of the grain and discharged into a trough or hopper. As the wheat kernels and wild oats are too long to remain in the pockets they are moved to another part of the machine in which the pockets are large enough to remove the wheat kernels from the wild oats. The wild oats and other coarse materials are then discharged from the machine into a separate spout.

The disk grain cleaner is built in sizes for use with threshing machines, in farm granaries, at country and terminal elevators, and in flour mills. Although the disk cleaner has been on the market less than 10 years, its use has become general throughout the spring-wheat area. The disk machine shown in Figure 15 was designed for farm use. In addition to removing cockle, wild buckwheat, wild peas, mustard, wild oats, tame oats, and barley from wheat by means of the pockets, machines of this particular design also remove chaff and dust by means of suction. This type of cleaner also separates either wheat and oat "succotash" or wheat and flaxseed "succotash" and at the same time cleans these grains. Tame buckwheat, rye, oats, barley, and flaxseed can also be cleaned without changing the disks.

The indented cylinder machine, shown in Figure 16, is used chiefly in elevators for general cleaning purposes. The large-size cylinder machines shown in this figure are used in making separations similar to those made by the disk machine.

The indented rubber-belt machine, shown in Figure 17, is designed for use on the deck of a threshing machine for taking the screenings out of wheat as part of the threshing operation. The light weight and large capacity of this cleaner makes its use possible for this purpose. The indents on the belt pick the wheat and small weed seeds out of the wild oats and other coarse screenings and carry the wheat and small seeds up and over into a screen section. The wild oats and other coarse materials are removed from the cleaner by an auger that extends through the end casing. The small weed seeds are cleaned out of the wheat by means of sieves in the screen section of the machine.

SPIRAL GRAVITY SEPARATORS

The spiral gravity separator, shown in Figure 18, requires no power, little attention, and small floor space. It is particularly use-

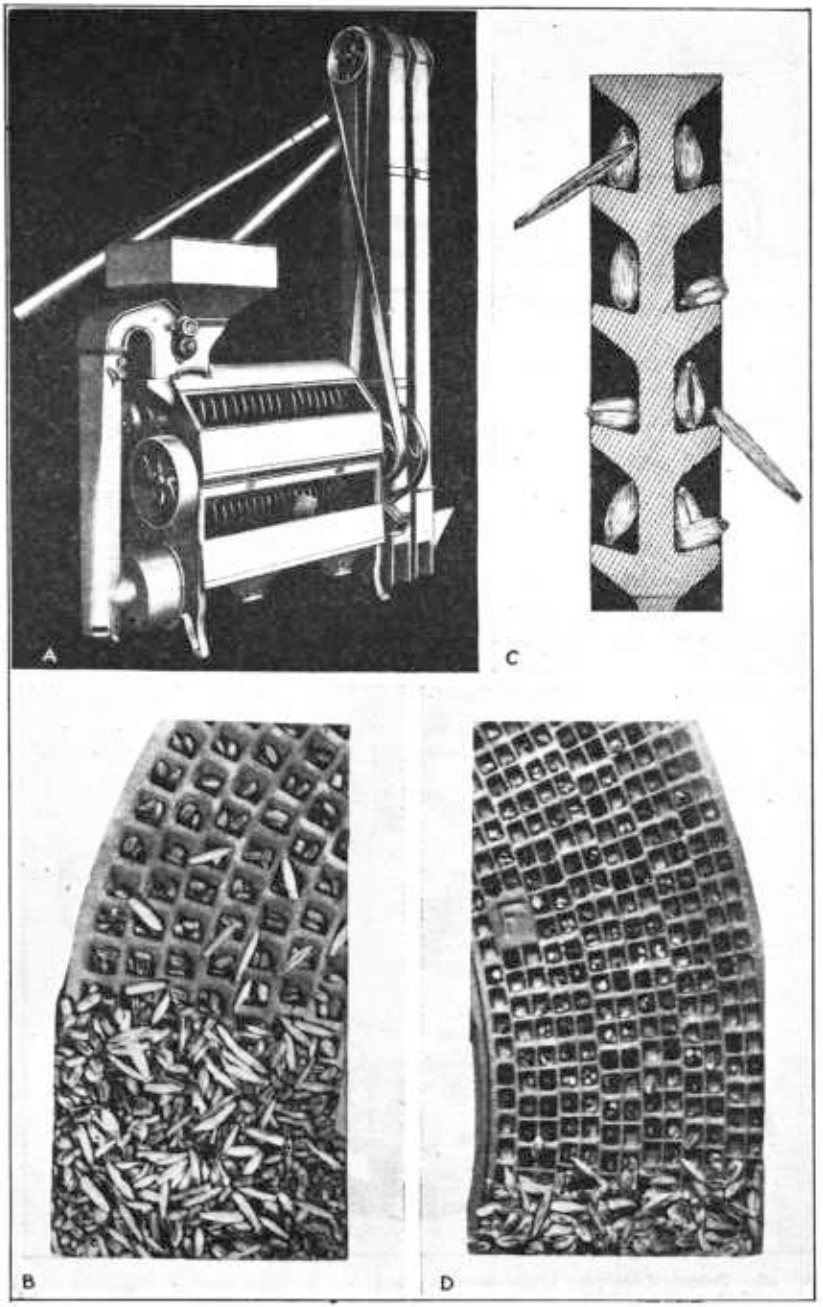
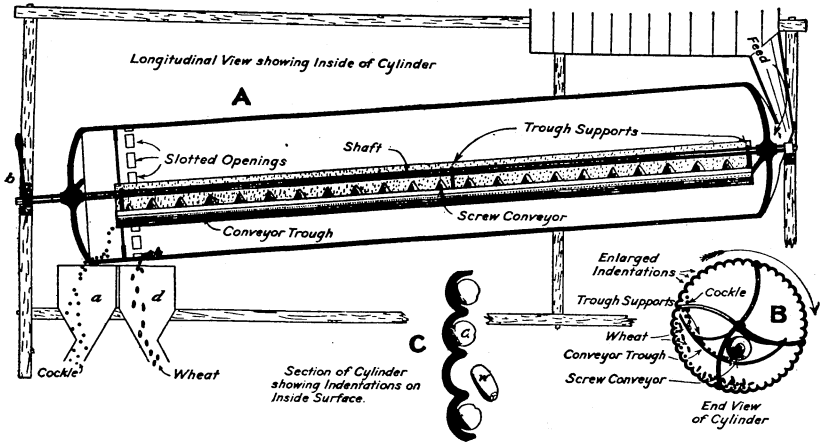


FIG. 15.—Disk grain cleaner. A, two rotors of cleaning disks with fan, scalper, and elevators; B, section of wheat disk in operation; C, cross section of wheat disk showing undercut pockets which pick up wheat kernels but discard oats; D, section of fine-seed disk, showing how small seeds are picked out of the wheat



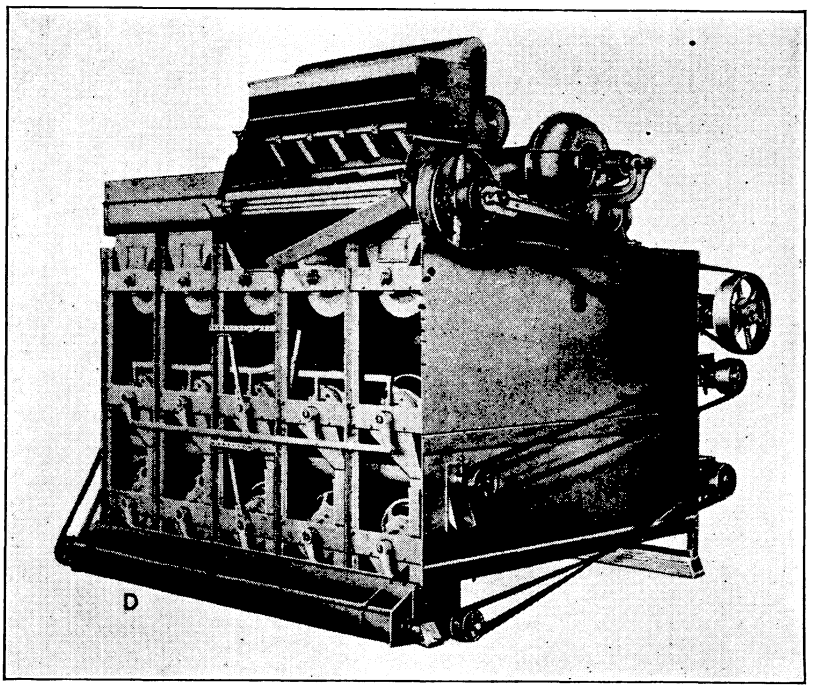


FIG. 16.—Indented cylinder grain-cleaning machine. A, cross section of a cylinder; B, end view of a cylinder; C, cross section of the indents showing how kernels of grain or weed seeds longer than the grain kernels to be removed fall out of the pockets as the cylinder rotates; D, a five-unit elevator type of indented cylinder machines containing cylinders for removing both coarse and fine seed dockage from grain

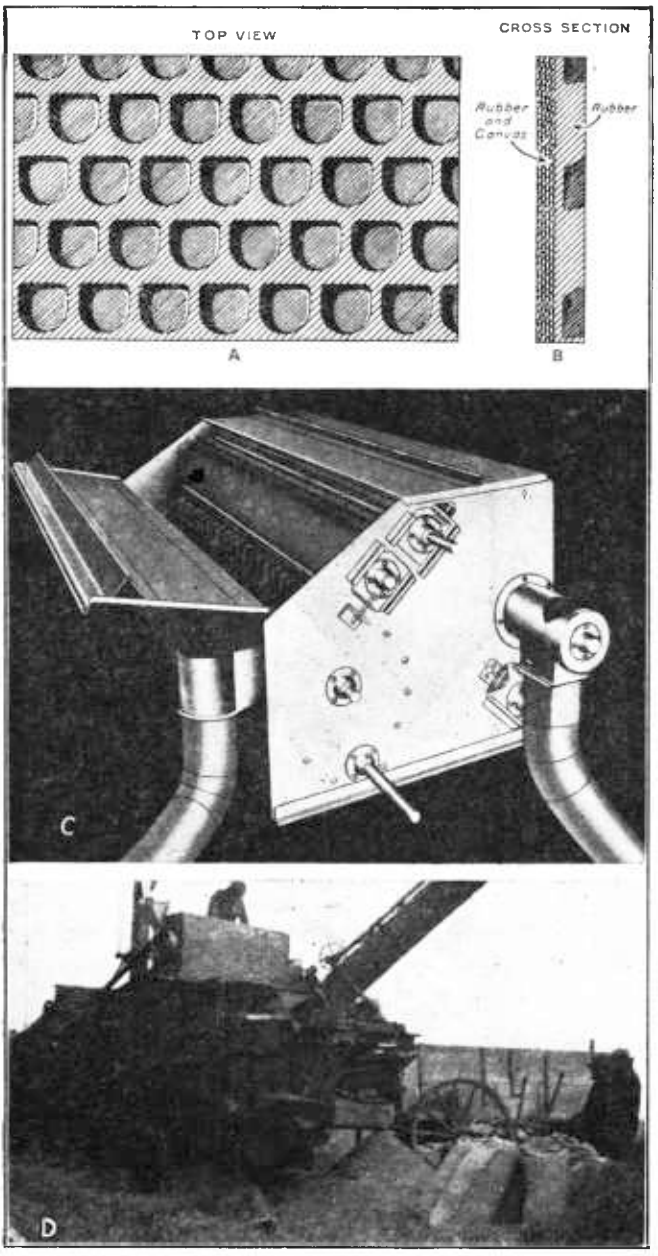


FIG. 17.—Indented rubber-belt grain-cleaning machine. The indented rubber-belt type of cleaning machine is designed for threshing machines. A, section of indented rubber belt; B, cross section of the belt showing canvas back and rubber face which contains "undercut" pockets that remove the wheat from either wild or cultivated oats; C, assembled belt machine ready for installation on threshing machine; D, belt machine in operation on a thresher, showing weed seeds that have been removed from the grain and piled on the ground

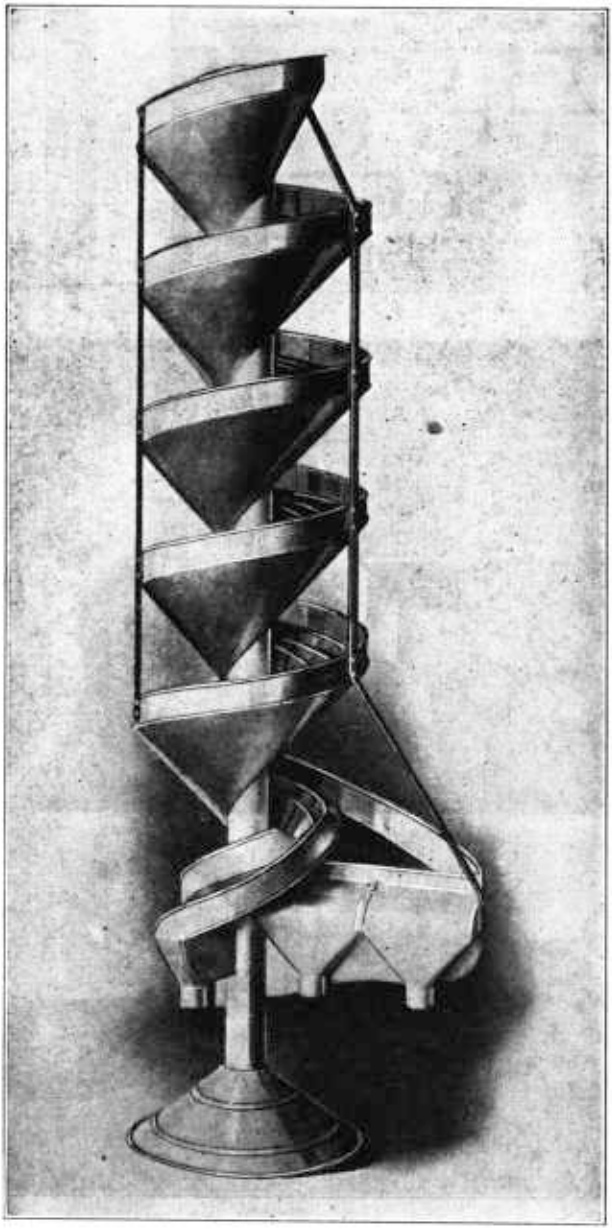


FIG. 18.—Spiral gravity separator. In operation the grain to be cleaned is fed into the spiral at the top. As the grain flows down the spiral the round weed seeds flow to the outer edge of the spiral and into a separate spout or container

ful for recleaning screenings or grain that contain the seeds of mustard, vetch, turnip, rape, wild peas, or other seeds that are spherical in shape. When such mixtures have had a preliminary cleaning to remove the coarse foreign matter and light dust, the spiral, by a combination of gravity and centrifugal force, makes a satisfactory separation of the round seeds from the grain.

In operation, the grain enters the cleaner at the top of the spiral and gathers momentum as it flows down the curved surface of the spiral toward the bottom. As the round weed seeds roll more readily than the grain kernels, which are semiround, they roll nearer the outer edge of the spiral and flow out in a stream near the outer edge of the spiral at the bottom of the machine. The grain kernels, which are less round, and any other angular seeds that may be present, are not carried very far from the center and are discharged in a separate stream close to the center of the spiral at the bottom of the machine. Thus, the round weed seeds and the grain kernels each flow in a separate stream and fall into different spouts at the base of the spiral. Spiral gravity separators vary somewhat in size but they are usually about 6 feet in height and 2½ feet in diameter. The capacity of a single spiral is small, about 5 bushels per hour.

CLOTH WILD-OAT SEPARATORS

The wild oat has an awn or barb, as shown in Figure 9, A, and this causes it to adhere to rough cloth. This feature of the wild-oat kernel is utilized in two types of cloth grain-cleaning machines which are used for separating wild oats from any kind of grain. In one of these cloth machines, flannel is placed on the inside of a rotating drum. In another type of machine the cloth forms an endless apron. In each of these cleaners the wild oats are carried up and out of the grain at an angle of 45° or more. The grain being cleaned will not adhere to the cloth at this angle. In using any of the cloth machines it is necessary that the cloth be replaced as soon as the loose nap on its surface has been worn off, for without the nap the wild oats will no longer cling to the cloth.

SPECIFIC GRAVITY SEPARATORS

The principle used in separating metallic ores according to their specific gravity by means of a vibrating cloth table, which is held on an inclined plane, and through which an air blast is forced upward, is made use of in one type of grain-cleaning machine. This type of machine is very efficient for grading grain according to the weight of the kernels, and is especially useful for preparing seed grain.

RING GRADERS

The ring-grader type of grain cleaner consists of a rotating cylinder made up of a large number of rings. The ring cylinder is mounted on a shaft and is nearly horizontal, but the feed end is slightly higher than its discharge end. In this way, as the cylinder rotates, the grain flows through the grader and the seeds to be removed fall through the openings between the rings. The rings are spaced differently, those at the feed end being close together and

allowing only the smallest and thinnest kernels to pass through, whereas the rings near the discharge end are farther apart and allow the separation of larger and thicker kernels. In some types of ring grades the spaces between the rings may be adjusted to permit the cleaning and grading of different kinds of grain.

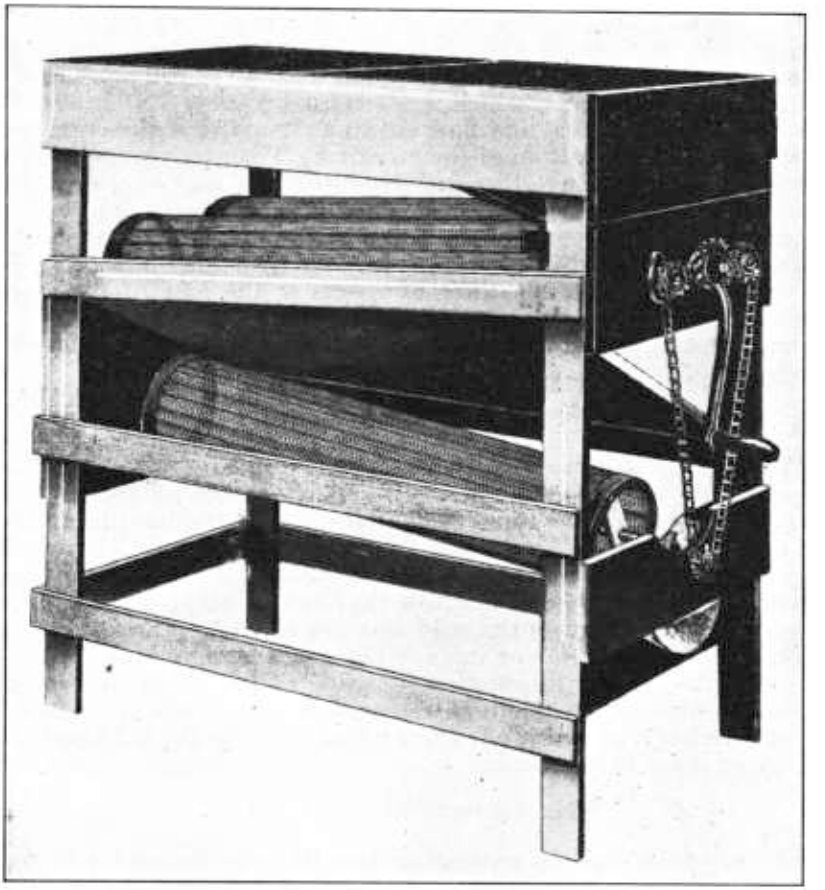


FIG. 19.—Three barley reels mounted for farm use. In operation the corrugated wire-mesh cylinders revolve and as they do so the small weed seeds present in the grain fall through the meshes of the screen and the wild oats and barley kernels are continually being made to roll over and upend. The wild oats kernels, having a smaller diameter than the barley kernels, fall through the openings in the screen, whereas the barley kernels are larger in diameter than the openings and are held back

BARLEY REELS

The barley reels shown in Figure 19 are designed to remove wild oats from barley, wild oats from large tame oats, and pin oats from wheat. The reels are made of woven-wire screen and are corrugated. As the reels rotate, the wild oats are upended and pass through the meshes of the screens and the grain is discharged at the lower end of the reels.

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